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Marsh

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(54) **METHOD FOR REDUCING RUB-OFF FROM TONER OR PRINTED IMAGES USING A PHASE CHANGE COMPOSITION**

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(51) **Int. Cl.**[7] **G03G 15/20**

(52) **U.S. Cl.** **399/341**; 399/324; 399/325

(58) **Field of Search** 399/324, 325, 399/341; 430/97, 124

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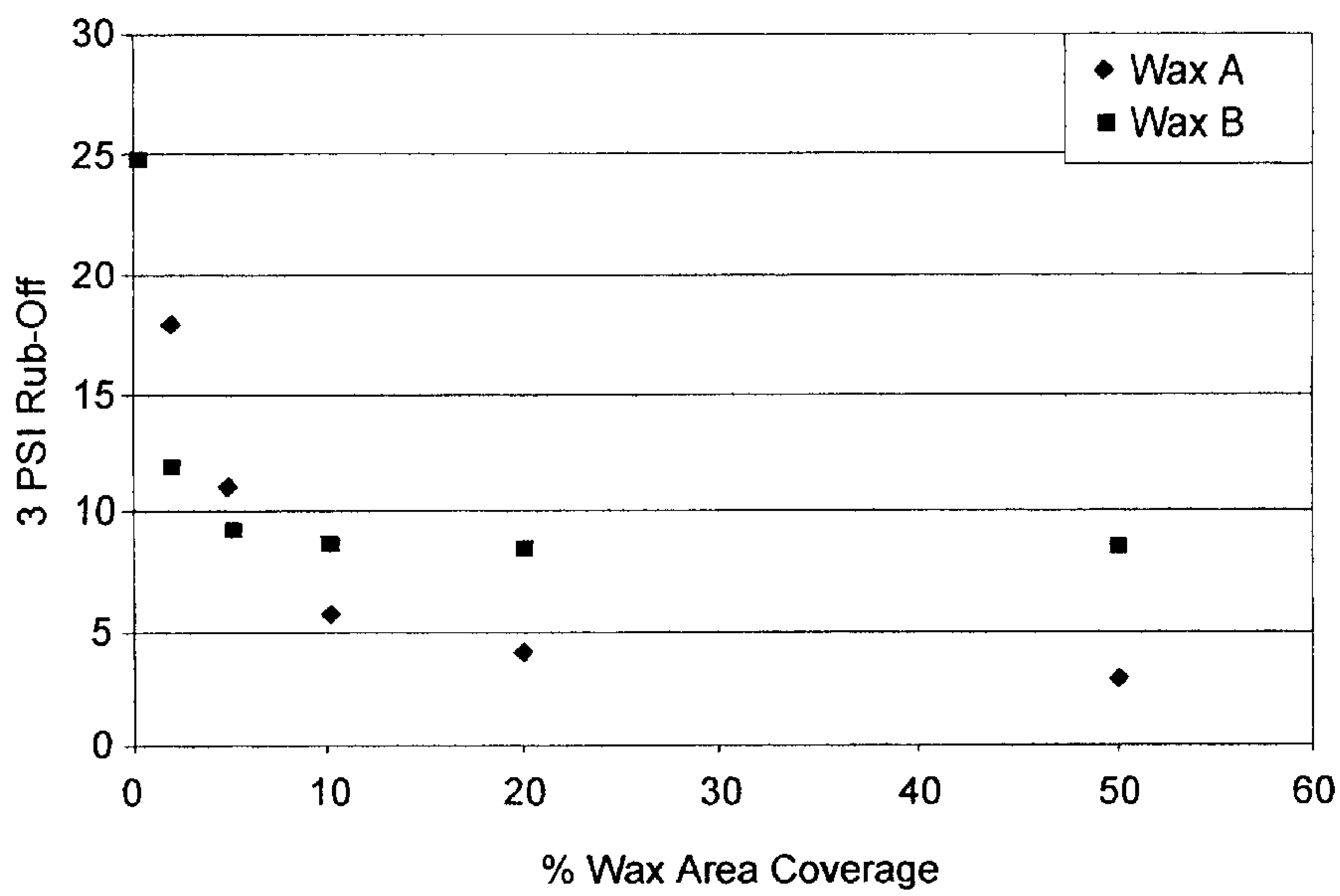
Primary Examiner—Hoang Ngo

(57) **ABSTRACT**

A method for reducing rub-off from a substrate having a front side and a back side with at least one side bearing a toner or a printed image by depositing a substantially clear phase change composition on the image bearing side of the substrate as a plurality of dots, with the plurality of dots cumulatively covering an area of the image bearing side sufficient to reduce rub-off from the image bearing side. The dots may also be applied only to the images rather than both the image-bearing and non-image-bearing surfaces of the substrate and may be used on both the front side and the back side if both bear images.

54 Claims, 4 Drawing Sheets



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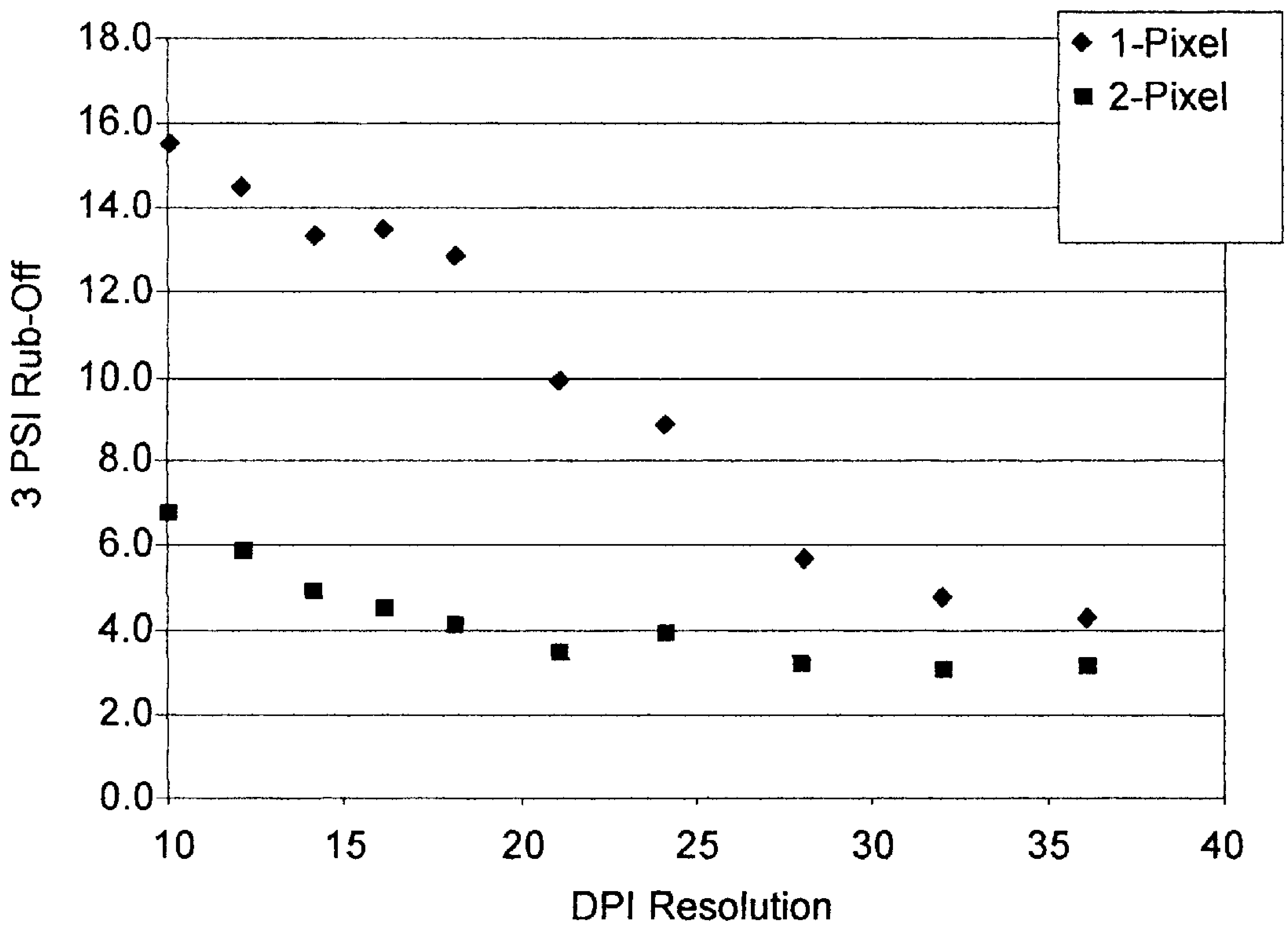
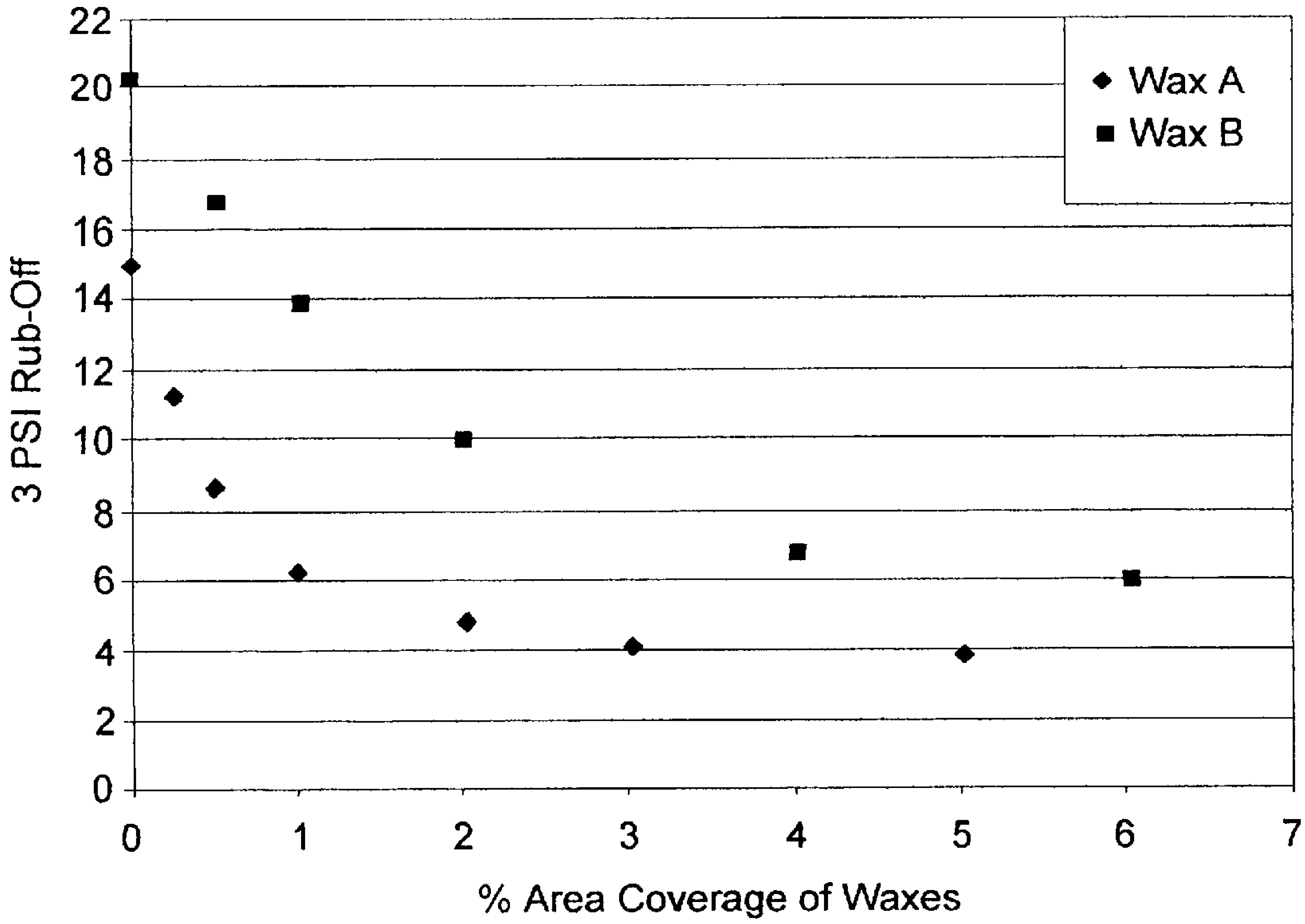

18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
3 PSI Rub-Off
10
15
20
25
30
35
40
DPI Resolution
1-Pixel
2-Pixel

FIG. 1



22
20
18
16
14
12
10
8
6
4
2
0
3 PSI Rub-Off
0
1
2
3
4
5
6
7
% Area Coverage of Waxes
Wax A
Wax B

FIG. 2

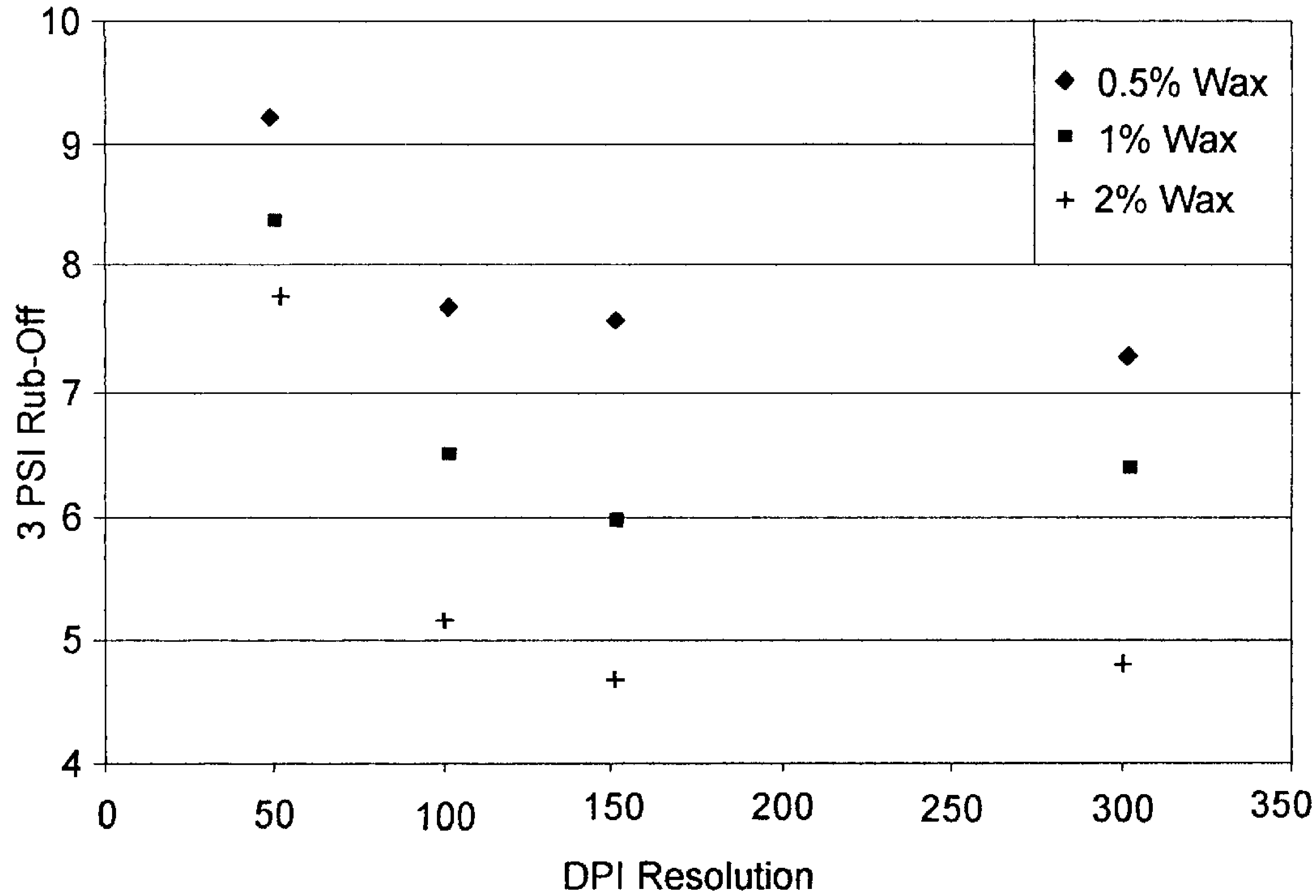

10
9
8
7
6
5
4
3 PSI Rub-Off
0
50
100
150
200
250
300
350
DPI Resolution
0.5% Wax
1% Wax
2% Wax

FIG. 3

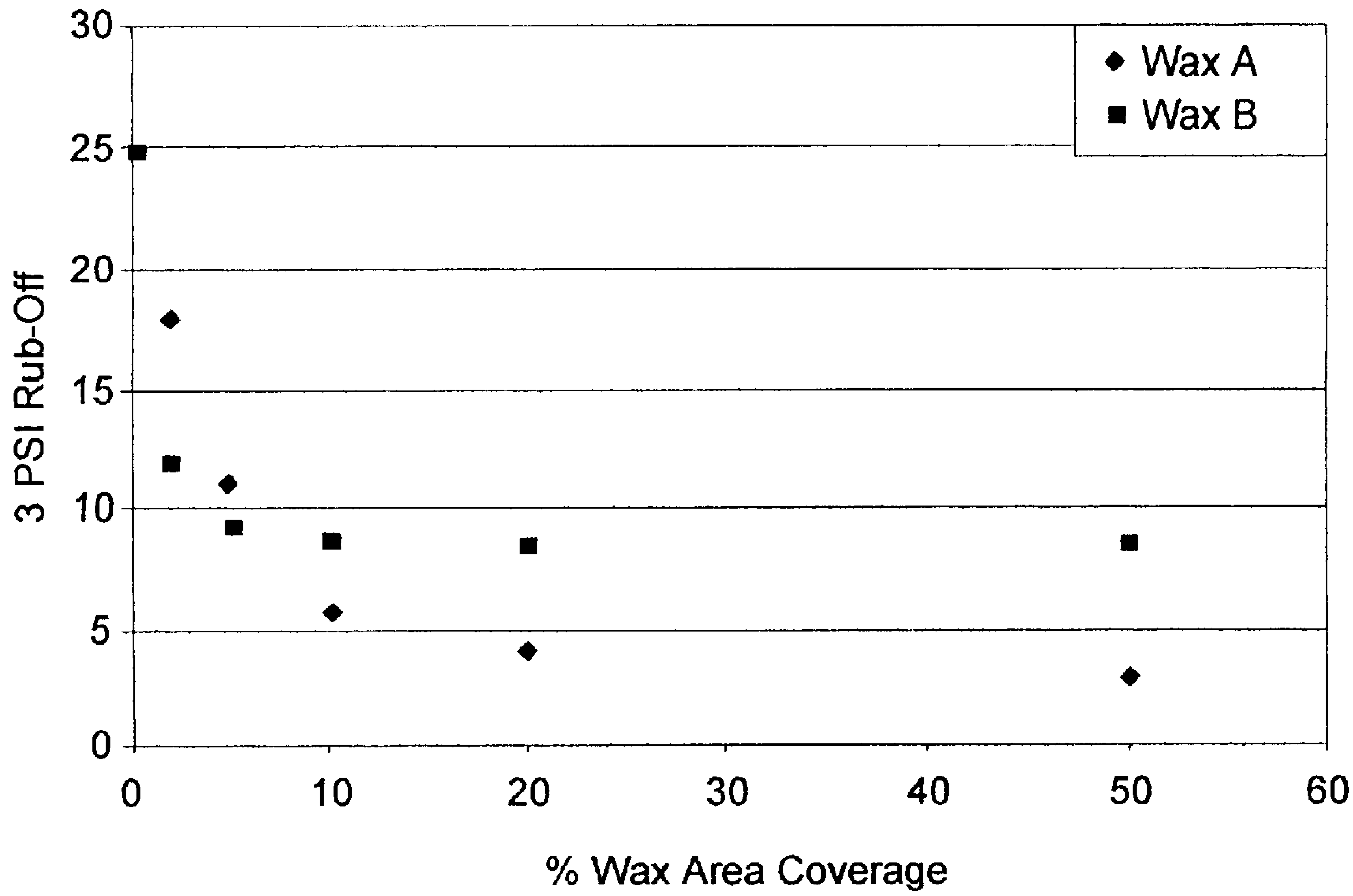

30
25
20
15
10
5
0
3 PSI Rub-Off
Wax A
Wax B
0
10
20
30
40
50
60
% Wax Area Coverage

FIG. 4

METHOD FOR REDUCING RUB-OFF FROM TONER OR PRINTED IMAGES USING A PHASE CHANGE COMPOSITION

RELATED APPLICATIONS

This application is entitled to and hereby claims the benefit of the filing date of U.S. provisional application No. 60/310,874 filed on Aug. 8, 2001.

FIELD OF THE INVENTION

This invention relates to a method for reducing rub-off from a substrate, such as paper, having a toner image on at least one side of the substrate by depositing a plurality of dots of a substantially clear phase change composition on the side of the substrate bearing the image with the dots cumulatively covering an area of the substrate bearing the image sufficient to reduce rub-off from the substrate. This invention further relates to the use of a phase change composition deposited on toner or printed images on a substrate to prevent rub-off from the substrate.

BACKGROUND OF THE INVENTION

In electrophotographic copying, digital copying, and printing processes, images are formed on selected substrates, typically paper, using small, dry, colored particles called toner. Toner usually comprises a thermoplastic resin binder, dye or pigment colorants, charge control additives, cleaning aids, fuser release additives and optionally, flow control and tribocharging control surface treatment additives.

The thermoplastic toner is typically attached to a print substrate by a combination of heating and pressure using a fusing subassembly that partially melts the toner into the paper fibers at the surface of the paper substrate. Additionally, the fused toner image surface finish can be controlled by the surface finish on the surface of the fuser roller. Thus, the gloss of the image may be controlled between diffuse (low gloss) and specular (high gloss). If the surface finish of the image is rough (diffuse) then light is scattered and image gloss is reduced.

Typically, in an electrophotographic printer, a heated fuser roller is used with a pressure roller to attach toner to a receiver and to control the image surface characteristics. Heat is typically applied to the fusing rollers by a resistance heater such as a halogen lamp. Heat can be applied to the inside of at least one hollow roller, and/or to the surface of at least one roller. At least one of the rollers is typically compliant. When the rollers of a heated roller fusing assembly are pressed together under pressure, the compliant roller deflects to form a fusing nip. Most heat transfer between the surface of the fusing roller and the toner occurs in the fusing nip. In order to minimize "offset," which is the amount of toner that adheres to the surface of the fuser roller, release oil is typically applied to the surface of the fuser roller. Typically, the release oil is silicone oil plus additives that improve attachment of the release oil to the surface of the fuser roller, and dissipate static charge buildup on the fuser rollers or fused prints. Some of the release oil becomes attached to the image and background areas of the fused prints.

Fused toner images can be substantially abraded or "rubbed-off" by processes such as duplex imaging, folding, sorting, stapling, binding, filing and the like. Residue from this abrasion process causes objectionable and undesirable marks on non-imaged areas of adjacent pages or covers. This process, and image quality defect, are known as "rub-off"

and exist to varying extents in many electrophotographic copies and prints. The basic "requirements" for generation of rub-off are a donor (toner image), a receptor (adjacent paper page, envelope, mailing label, etc.), a differential velocity between donor and receptor, and a load between donor and receptor.

In general, mechanisms of rub-off are consistent with those of abrasive and adhesive wear mechanisms. Relevant factors include: toner toughness, toner brittleness (cross-linking density), surface energy or coefficient of friction of the toner, adhesion of the toner to the paper substrate, cohesive properties of the toner itself, the surface topography of the toner image, the level of load and the differential velocities of the wearing surfaces. Some of these factors are under the control of the machine and materials manufacturers, and some are under the control of the end user.

Toner rub-off may be reduced by the use of tougher toner, lower surface energy toner materials (resulting in lower coefficient of friction), better-fused toner, and a smoother toner image surface finish (but this increases image gloss.)

Unfortunately, there are undesirable consequences associated with each of the above rub-off reduction factors. A tougher toner is more difficult to pulverize, grind, and classify which increases manufacturing costs. Additionally, smaller toner particle size distributions are more difficult to achieve with tougher toner. Adding wax to the toner may provide additional release properties from the fuser roller surface, and add lubrication to the surface of the toner, but triboelectric charging behavior may be adversely affected. A more easily fusible toner may create more toner offset to the surface of the fuser rollers, or increase the tendency of fused prints or copies to stick together in the finisher or output trays. Creating a more specular (smoother) image surface finish increases image gloss, which may be objectionable in some applications. Fuser release oil can lower the coefficient of friction of the fused image, but this effect is temporary since the oil is adsorbed into the paper substrate over time. Fuser release oil can also cause undesirable effects in the rest of the electrophotographic process, especially in duplex printing operations. Extensive efforts have been directed to the development of improved methods for reducing rub-off without modification of the fusing process.

SUMMARY OF THE INVENTION

According to the present invention, rub-off from a substrate bearing a toner image is reduced by a method for reducing rub-off from a substrate having a front side and a back side and bearing a toner image on its front side, the method comprising: depositing a substantially clear phase change composition on the front side of the substrate as a plurality of dots, the dots cumulatively covering an area of the front side sufficient to reduce rub-off from the front side.

The invention further relates to a method of reducing rub-off from a substrate having a front side and a back side and a plurality of printer or digital copier produced toner or printed images on its front side, the method comprising: depositing a substantially clear phase change composition on at least a portion of the toner or printed images as a plurality of dots, the dots cumulatively covering an area of the toner or printed images sufficient to reduce rub-off from the front side.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the test results from Example 2;

FIG. 2 graphically shows the test results from Example 4;

FIG. **3** graphically displays the test results from Example 5; and

FIG. **4** shows the test results from Example 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Many electrophotographic processes produce prints or copies, which have a high rub-off of toner onto adjacent receiver sheets that is considered unacceptable by some users. The amount of rub-off depends upon the particular machine hardware, oiling rates and the like. Typical values from 19 to 25 are measured at 3 psi (pounds per square inch) using the test procedure described herein for copies that have been aged for about 100 hours.

The existing toners in some instances do not have a wax lubricant and offer little protection against rub-off. The electrophotographic process typically forms images on selected substrates, which are typically paper, using small, dry, colored particles called toner. Toners usually comprise a thermoplastic resin binder, dye or pigment colorants, charge control additives, cleaning aids, fuser release additives and, optionally, flow control and tribocharging control surface treatment additives.

The thermoplastic toner is typically attached to a print substrate by a combination of heat and pressure using a fusing subassembly that partially melts the toner into the paper fibers at the surface of the paper substrate. The fused toner image surface finish is affected by the fuser roller surface finish. Thus, the gloss of the image may be controlled between diffuse (low gloss) and specular (high gloss). When the surface finish of the image is rough, the light is scattered and image gloss is reduced.

Typically in an electrophotographic printer a heated fuser roller is used with a pressure roller to attach toner to a receiver and to control the toner image surface characteristics. Heat is typically applied to the fusing rollers by a resistance heater such as a halogen lamp. Heat can be applied to the inside of at least one hollow roller, and /or to the surface of at least one roller. At least one of the rollers is typically compliant. When the rollers of a heated roller fusing assembly are pressed together under pressure, the compliant roller deflects to form a fusing nip. Most heat transfer between the surface of the fusing roller and the toner occurs in the fusing nip. In order to minimize "offset," which is the amount of toner that adheres to the surface of the fuser roller, release oil is typically applied to the surface of the fuser roller. Typically, the release oil is silicone oil plus additives that improve attachment of the release oil to the surface of the fuser roller, and dissipate static charge buildup on the fuser rollers or fused prints. Some of the release oil becomes attached to the image and background areas of the fused prints.

Certain characteristics of the fused toner image are inherent. Since the fused toner is only partially melted, it does not completely penetrate into the paper fibers on the surface of the paper. The toner image forms a relief image and projects above the surface of the paper. The height of the toner image above the surface of the paper substrate is dependent on the particle size of the toner particles. Small particles result in a lower image height.

The thermal-mechanical properties of the toner, such as melting point, glass transition temperature, and rheological flow characteristics also affect rub-off. Fused toner images can be substantially abraded or rubbed-off by processes such as duplex imaging, folding, sorting, stapling, binding and filing. Residue from this abrasion process causes objectionable and undesirable marks on non-imaged areas of adjacent pages or covers. This image quality defect is known as rub-off and is common on many electrophotographic copies and prints. The basic requirements for generating rub-off are a donor (toner image), a receptor (adjacent paper page, envelope, mailing label, etc.), differential velocity between donor and receptor, and a load pressing the donor against the receptor.

In general, the mechanisms of rub-off are consistent with those of abrasive and adhesive wear mechanisms. Relevant factors include: toner toughness, toner brittleness (crosslinking density), surface energy or coefficient of friction of the toner, adhesion of the toner to the paper substrate, cohesive properties of the toner itself, the surface topography of the toner image, the level of load and the differential velocities of the wearing surfaces. Some of these factors are under the control of the machine and materials manufacturers, and some are under the control of the end user.

Toner rub-off may be reduced by the use of tougher toner, lower surface energy toner materials (resulting in a lower coefficient of friction), better-fused toner, and a smoother toner image surface finish (but this increases image gloss).

Unfortunately, there are undesirable consequences associated with each of the above rub-off reduction factors. A tougher toner is more difficult to pulverize, grind, and classify which increases manufacturing costs. Additionally, smaller toner particle size distributions are more difficult to achieve with tougher toner. Adding wax to the toner may provide additional release properties from the fuser roller surface, and add lubrication to the surface of the toner, but triboelectric charging behavior may be adversely affected. A more easily fusible toner may create more toner offset to the surface of the fuser rollers, or increase the tendency of used prints or copies to stick together in the finisher or output trays. Creating a more specular (smoother) image surface finish increases image gloss, which may be objectionable in some applications. Fuser release oil can lower the coefficient of friction of the fused image, but this affect is temporary since the oil is adsorbed into the paper substrate over time. Fuser release oil can also cause undesirable effects to the rest of the electrophotographic process, especially in duplex printing operation. Wax jet technology, which applies phase change or hot melt wax to pre-printed paper documents, is a technique for reducing toner rub-off that is not susceptible to the above-mentioned disadvantages.

Hot melt type inks, also referred to as phase change inks, typically comprise a carrier such as a polymeric or wax material and a colorant. Ink jet printing systems and other phase change composition systems are known to those skilled in the art.

Many suitable carrier materials are known for phase change printers. When the ink is omitted from these materials, they basically comprise a carrier for the ink, without the colorant. Many of these materials are substantially colorless.

Ink jets typically provide the capability of providing a resolution of about 300 or more dpi (dots per inch). When printing a square matrix with an ink jet printer, it is possible to print with a resolution equal to 300 dpi in both a cross-track and in-track direction. This produces a square of print dots referred to as a matrix, which contains the potential for 300 dots along each axis. This resolution provides excellent print quality. Ink jet print heads having lesser resolution of 50×300, 100×300, 200×300 dpi and the like are also available. Further, ink jet print heads having a

300×300 resolution can be programmed to produce dots at a lesser cross-track frequency. Such jets produce single pixel ink drops, which are ejected from the jet onto the substrate where they instantly solidify. The single pixels are typically from about 12 to about 14 microns in height and form a dot which is typically about 83 microns in diameter and which typically contains about 80 nanograms of material per pixel. Such ink jet printers are considered to be well known to those skilled in the art and are readily available.

Phase change inks (hot melt inks) are desirable for ink jet printers because they remain in a solid state at room temperature during storage and shipment. In addition, problems associated with nozzle clogging due to ink evaporation are eliminated and improved reliability of ink jet printing is achieved. When the drops of the hot melt ink are applied directly onto a substrate such as paper, the drops solidify immediately on contact with the substrate and migration of ink on the surface of the substrate is prevented.

Hot melt waxes developed for full process color printing in graphics arts applications contain a wax vehicle, colorants, surfactants and dispersants to enable compatibility of the dye with anti-oxidants, cross-linking agents and the like. These waxes are also desirably modified to prevent crystallinity that will negatively impact the color hue.

Colorless hot melt waxes for use in rub-off reduction of electrophotographic toner images do not require surfactants, dispersants or dye. They may contain slip agents, such as organic stearates, to provide low surface energy properties to avoid offsetting of the wax material to receiver substrates. These waxes are preferentially crystalline to enable low gloss. Therefore, high melting waxes with sharp melting point ranges are desirable. Preferably, the waxes or other polymeric materials used have a melting point from about 80 to about 130° C. with a melting range (starts-to-melt to starts-to-freeze range) of about 15° C., and desirably about 10° C. Desirably these waxes or other polymeric materials are crystalline in solid form, have a low coefficient of friction and are odorless. Some suitable materials are waxes, polyethylene, polyalphaolefins, and polyolefins.

U.S. Pat. No. 5,958,169 discloses various hot wax compositions for use in ink jet printers. U.S. Pat. No. , 6,018,005 discloses the use of urethane isocyanates, mono-amides, and polyethylene wax as hot melt wax compositions. The polyethylene is used at about 30 to about 80 percent by weight and preferably has a molecular weight between about 800 and about 1200.

U.S. Pat. No. 6,028,138 discloses phase change ink formulations using urethane isocyanate-derived resins, polyethylene wax, and a toughening agent. U.S. Pat. No. 6,048,925 discloses urethane isocyanate-derived resins for use in a phase change ink formulation. Both of these references disclose the use of a hydroxyl containing toughening agent.

Additional formulations are disclosed in U.S. Pat. Nos. 5,922,114; 5,954,865; 5,980,621; 6,022,910; and, 6,037,396.

U.S. Pat. No. 5,994,453 discloses phase change carrier compositions made blocking properties to the prints and to provide enhanced document feeding performance of the ink-bearing substrates for subsequent operations, such as photocopying. This reference discloses the use of printing comprising images of phase change waxes, which are treated by over-spraying the substrate bearing the images of phase change waxes. The reference does not address in any way the treatment of substrates bearing toner images. Toner images, as discussed above, are radically different than phase change ink images in their properties. Further, this

reference does not address the reduction of rub-off from toner images or the use of a phase change material to cover selectively the area of the printed images.

All of the patents noted above are hereby incorporated in their entirety by reference.

According to the present invention, rub-off of toner images from a substrate having a front side and a back side and bearing a toner image on its front side is reduced by depositing a plurality of dots of a substantially clear phase change composition on the front side of the substrate with the dots cumulatively covering an area of the front side sufficient to reduce rub-off from the front side.

The dots are deposited by an ink jet printer and may cumulatively cover from about 0.25 to about 8.00 percent of the total area of the front side of the substrate. Preferably, the coverage is from about 0.25 to about 6.00 percent. Typically, the dots are deposited in a matrix pattern since the ink jet head is capable of depositing the dots as a plurality of pixels at a spacing of 300×300 dpi. Desirably, the dots as positioned on the substrate have a resolution from about 50×300 to about 300×300 dpi and preferably; the resolution is at least about 100×300 dpi.

The dots may be arranged in a plurality of patterns. For instance, the dots may be arranged in a square matrix pattern. Such square matrix patterns suffer the disadvantage that when a second sheet in contact with a first sheet bearing a toner image is moved relative to the first sheet, the rub-off can occur in streaks corresponding to the area between the dots. Another configuration comprises the use of lines of dots. These lines can be placed in any orientation from perpendicular to or diagonal to the anticipated line of movement of a contacting second page of paper or the like. Further, the lines can be used in a square matrix. In any instance, it is desirable that the lines be spaced at a distance less than about 1 (one) inch.

Preferably, the dots are arranged in a random matrix pattern. The use of the random matrix arrangement results in a dot pattern, which provides relatively uniform protection whichever way the substrate is moved relative to a second page.

As is well known, the dots typically include about 20 to about 80 nanograms of phase change material and typically have a height of about 10 to about 16 microns. More typically, the height of the dots is from about 10 to about 12 microns. This is roughly the same as the height of the toner image typically produced on a paper substrate. In some instances, it may be desirable to place a second dot on top of a previous dot. Such is readily accomplished by the use of ink jet printers since the drops can be duplicated at the same location. In such instances, the height of the dot may be from about 20 to about 30 microns above the substrate surface. Of course, such doubled dots will contain double the amount of phase change material. Further, the dots may be formed as a plurality of pixels to form, for instance, a period. Typically, a period sized dot would contain 4 pixels of material, which might contain from about 80 to about 320 nanograms of phase change composition, and be from about 10 to about 16 microns in height above the substrate. It has been found that the use of such dots on the substrate surface is effective to greatly reduce the rub-off of the toner image when the toner image is brought into contact with another substrate and moved relative to the other substrate.

Typically, the phase change composition is selected from the group consisting of polymeric materials and waxes having a melting point from about 80 to about 130° C., a melting point range of less than about 15° C., a crystalline form as a solid, a static coefficient of friction less than about 0.62, and being substantially odorless. Desirably, the melting range is less than about 10° C. Typically, the phase change material comprises at least one component selected from the group consisting of waxes, polyethylene, polyalphaolefins, and polyolefins and may contain a friction reducing material such as an organic stearate or the like. Most phase change compositions suitable for use in ink jet printers are suitable for use in the present invention if they meet the physical requirements set forth above.

Further, the substrate may have a toner or a printer image on both the front side and the back side of the substrate. The phase change composition may be deposited on both sides of the substrate as discussed above. The most commonly used substrate is paper.

The present invention is also useful to reduce rub-off from a substrate having a front side and a back side and bearing printer or digital copier produced printed images on its front side by depositing a substantially clear phase change composition on at least a portion of the printed images as a plurality of dots. The dots cumulatively cover an area of the printed images sufficient to reduce rub-off from the front side. Typically, this area is from about 0.25 to about 8.00 percent of the image area. Preferably, this area is from about 0.25 to about 6.00 percent of the image area. The printed images may be produced by the use of conventional phase change ink printing or by other conventional printing processes known to them art.

With either toner or printed images the dots are deposited with an ink jet printer as discussed previously and the dots, as discussed previously, are desirably arranged in a matrix pattern with a resolution from about 50×300 to about 300×300 dpi. Desirably, the resolution is at least about 100×300 dpi. The properties of the dots and the composition of dots are as discussed previously. The dots may be positioned on the images over either the entire image at the desired spacing or they may be positioned selectively as one or more row of pixels at a desired spacing around the outside of the images. The amount of phase change material applied to the images in this fashion is determined by an evaluation of the amount of material required to reduce rub-off to a desired level.

The dots may also or alternatively be applied to the area immediately surrounding the images. This results in desirable protection with a reduced amount of phase change material. The dots may be placed either on the image, around the edges (rim) of the images around but not on the images or in any other desired pattern on or around the image or in any combination of dots positioned on or around the image. The areas adjacent to the image, which are selected for positioning of dots, can vary widely but are desirably areas adjacent to the image and preferably the dots are spaced within a distance up to from 1 to 2 times the distance across the image from the image.

It is considered that while the present invention is effective with both printed and toner images, the invention is most effective with toner images.

The use of the dots in this fashion results in a marked reduction of the rub-off. Typically, the rub-off from an untreated page bearing a dense printed toner image pattern is from about 19 to about 25 using a 3-psi weight using the test procedure discussed hereinafter.

All rub-off test results reported below were made with the test procedure below.

Test Procedure

The Test Procedure used basically involves the use of a selected weight positioned on top of a receiver sheet, which is a clean sheet of paper positioned above a toner image-bearing sheet positioned with an image-bearing side facing the receiver sheet. The toner image-bearing sheet is then slid a controlled distance under the weight on the upper sheet. The resulting discoloration of the upper sheet is then compared to a standard to produce a numeric indication of the degree of rub-off. The degree of rub-off from a clean sheet is 3.0. The rub-off of untreated toner image-bearing copies is typically from about 19 to about 25. Typically, a standard test pattern is used to test the efficiency of the dot distribution. The test sheets used for the tests herein are referred to in the copying industry as Gutenberg sheets. These sheets are sheets of alternating very closely spaced lines of images of varying sizes. Desirably, a standard image of this type is used for all tests. The dots or other treatment applied is then readily evaluated for efficacy in reducing rub-off. As indicated above, the weight used for all tests in this application was 3 psi and the tests were performed by comparing all of the samples to the same set of standards to determine rub-off evaluation numbers.

Further, rubbed patches resulting from the tests were analyzed as follows:

a) six rub-off patches were produced for each test. These test patches were first scanned on a calibrated scanner with the resulting scans or image being saved using a standard format;

b) the patch image was then evaluated and a standard deviation of the density values from each patch is calculated. Applications such as Pro Shop or Math Cad can be used. It has been demonstrated that the results are identical. The standard deviation, so long as the mean density is below 0.30, has been shown to correlate with the subjective measures of the amount of toner on the sheets evaluated;

c) the standard deviations of each patch were then averaged and the statistics provided for the test samples; and,

d) the average of the six standard deviations was reported as the rub-off value for any particular test.

The test sheets, as indicated, are sheets with densely spaced images across the surface of the paper. To avoid any tendency to form streaks in the test apparatus, the test sheet was turned to an angle of 7 (seven) degrees relative to the direction of movement relative to the top clean sheet. The 7-degree angle has been selected arbitrarily and can be any suitable angle so long as the printed sheet is turned to a sufficient extent to avoid a tendency to streak as a result of pulling the same letters of the sheet under the weighted area of the clean test sheet along the path of the test sheet.

EXAMPLE 1

A suitable test method is disclosed in U.S. patent application, U.S. Ser. No. 09/804,863 filed Mar. 13, 2001 by John Lawson, Gerard Darby, and Joe Basile, entitled Rub-off Test Method and Apparatus.

A plurality of tests was run using square matrix arrays. 16×16 dpi matrix patterns of dots using Times New Roman font at 3, 4, 8, 12, 16 and 20 points were generated. These dots, comprising a plurality of pixels, were applied to pre-printed documents on Hammermill 20 weight paper. Rub-off was measured as described above at 3 psi load on documents bearing toner images which had been aged for about 100 hours. A non-treated control was used for comparison. The data is shown below in Table 1.

TABLE 1

Point	% Area Coverage	3-PSI Rub-off
Control	0.00	15.0
3	0.34	10.2
4	0.61	10.8
8	2.43	6.7
12	5.10	6.5
16	8.00	6.9
20	16.9	5.2

EXAMPLE 2

A second set of experiments was run using Times New Roman 4 point period in a series of dpi resolution square matrix arrays. The arrays were generated with single spots of wax at each matrix location, and double spots of wax at each matrix locations. (For a single spot of wax corresponding to the four-point period, the print head used actually prints four single pixel drops of wax.) These are deposited on the page as four nearest neighboring drops of wax. The 3-psi rub-off data is shown in FIG. **2**. With the single drops of wax applied at spacings from 10×10 dpi resolution to a value of 36×36 dpi, the rub-off decreased from about 15 to about 4.

On some of the tests, a second drop was placed on top of the first drop by simply applying a second dot on top of the first dot. For these tests, the values for the same spacings decreased from about 7 to about 3. These tests results demonstrate that more wax in the dots coupled with higher height drops results in better rub-off protection. The major heights of the single drops of wax are about 12 to 14 microns. The major heights for the two spots is about 20 to about 24 microns. These spots of wax apparently act as small standoffs that keep the toner image from rubbing against the adjacent receiver material. The spots of wax also apparently allow wax to be spread and smeared against the adjacent receiver sheets to further offer rub-off protection. These spots could be considered to function as sacrificial pylons.

The test results are shown in FIG. **1**.

EXAMPLE 3

Patterns of horizontal lines at spaced distances from each other were tested as a potential way to reduce rub-off. These lines offer rub-off protection when the direction of abrasion against an adjacent sheet is orthogonal to the lines. Patterns using horizontal and vertical lines (ladder patterns) would provide rub-off protection in all directions. The ladder patterns may be produced with either single or double height lines. Both were tested and it was discovered in both instances that it is desirable that the lines be spaced at a spacing less than one inch. At spacings greater than one inch, the rub-off protection is much less than that achieved at one inch or less.

EXAMPLE 4

Random dot patterns were generated using a random number generator. These patterns enabled the print head to emit a single pixel drop of wax of approximately 83 microns in diameter with a mass of about 80 nanograms per drop. The random patterns were used to apply wax to comparable documents. Different wax coverage is achieved by selecting a percentage of the available dots per square inch for the 300×300 dpi print resolution. For instance, five percent area coverage is a pattern in which 4,500 drops per square inch are utilized. Two waxes were used to generate random dot patterns. One wax was a polyethylene wax and the other wax was a blend of two polyalphaolefin waxes. The random dots were applied to cover varying area percentages and the 3-psi rub-off data from these tests using the two waxes is shown. The test results are shown in FIG. **2**.

The test results indicate that Wax A, which was somewhat harder than Wax B, was more effective in reducing rub-off. Wax A had a melting point of about 62–64° C., and a melting range of about 10° C. Wax B had a melting point of about 60–63° C. and a melting range of 10° C.

EXAMPLE 5

A series of tests were run using random dot patterns at different dots per square inch resolutions. Tests were run at wax application levels of 0.5 percent, 1.0 percent and 2.0 percent. The test results are shown in FIG. **3**.

The 0.5 percent wax area coverage data is represented in FIG. **3** by the solid diamonds. The rub-off values decrease from about 9 down to about 7.3 as the cross-track dots per square inch resolution increases from 50 dpi to 300 dpi. The trends for the 1.0 and 2.0 percent areas coverage are similar except that the rub-off values decrease to 6.5 and 4.8 respectively. This data suggests that for patterns using random dot patterns, a 300×300 dpi resolution print head may not be required since the improvement at a 100×300 dpi range print head would appear to provide almost the same rub-off protection as the more expensive 300×300 dpi print head. Thus, a 100×300 dpi print head would provide a 3-psi rub-off value of less than 5 while using less wax material. This enables a savings in coating materials as well as in the unit manufacturing costs for the ink jet print head.

EXAMPLE 6

The characters in any font set produced by a printer or digital copier may be used with a wax jet print head to select areas, which may be coated by wax. In other words, a 300×300 or other suitable dot per inch resolution print head may be used once the software (generated for printing or copying) is available for the generation of the instructions to coat only the characters. This would enable the use of less wax while still achieving desirable rub-off protection. The test results are shown in FIG. **4**. The data represented in FIG. **4** by solid diamonds uses a polyethylene wax, which is applied on top of the toner images and nowhere else. A second wax, shown as Wax B, was also tested. The amount of wax used is minimized and the rub-off protection is maximized. Since the background areas contribute no rub-off there is no need to put wax in these areas. At about 10 percent area coverage of the characters, the rub-off value is reduced to about five. The percent wax coverage refers only to the percent coverage of the area of the images. The polyethylene wax used and shown as Wax A provides very good coverage at 10 percent area coverage of the images. Good coverage is also included at higher area coverages for the images. In fact, substantial improvement is achieved as low as five percent coverage. Wax B used was a softer polyalphaolefin wax mixture, which did not produce as good rub-off protection. This wax is not considered to provide the same height of wax as the harder polyethylene wax. Wax A had a melting point of about 62–64° C., and a melting range of about 10° C. Wax B had a melting point of about 60–63° C. and a melting range of 10° C.

Tests were performed to determine whether the presence of the dots on the substrate resulted in any substantial change in the appearance. On balance, the conclusion was that no apparent difference resulted from the use of the dots on the substrate to produce the reduced rub-off.

It should be well understood that the use of the method of the present invention can be implemented by the use of an ink jet printer or the like to coat substrates bearing a toner image as they are produced in a printer or copier machine. The prints can be produced photoelectrically, digitally or the like. Further, the ink jet dot application system may be implemented as a part of the photocopier or printer machine, or as a stand-alone unit, which may apply rub-off reducing material in a separate step.

Many variations are possible within the scope of the present invention and many such variations may be considered obvious and desirable by those skilled in the art. For instance, a wide variety of wax and polymeric materials having the physical properties set forth above may be found effective. Further, it may be found desirable to imprint an indication of reduced rub-off treatment at the same time as the dots are applied in order to provide promotional labeling for treatment by the method of the present invention or it may be desirable to print colored images over a portion of the substrate as the dots are applied. Such variations are considered to be well known to those skilled in the art.

As discussed previously, the development and use of a variety of polymeric and wax materials having suitable properties for use in ink jet printers for use as carriers for phase change inks and the like are well known. Many of these materials have been shown in patents referred to herein and in other patents available as open literature. Further, the use of ink jets is well known to those skilled in the art and a variety of systems for applying ink jet images to substrates is available on the open market.

Having disclosed the present invention by reference to certain of its preferred embodiments, it is respectfully pointed out that the embodiments described are illustrative rather than limiting in nature and that many variations and modifications are possible within the scope of the present invention. Many such variations and modifications may be considered obvious and desirable by those skilled in the art based upon the foregoing description of preferred embodiments.

Having thus described the invention, I claim:

1. A method for reducing rub-off from a substrate having a front side and a back side and bearing a toner image on its front side, the method comprising: depositing a substantially clear phase change composition on the front side of the substrate as a plurality of dots, the dots cumulatively covering an area of the front side sufficient to reduce rub-off from the front side.

2. The method of claim **1** wherein the dots cumulatively cover from about 0.25 to about 8.00 percent of the area of the front side of the substrate.

3. The method of claim **1** wherein the dots are deposited on the front side of the substrate by an inkjet printer.

4. The method of claim **3** wherein the dots are arranged in a matrix pattern.

5. The method of claim **4** wherein the dots are deposited by an ink jet printer having a cross-track to in-track resolution from about 50×300 to about 300×300 dpi.

6. The method of claim **5** wherein the resolution is at least about 100×300 dpi.

7. The method of claim **4** wherein the dots are arranged in a square matrix array.

8. The method of claim **4** wherein the dots are arranged to form lines.

9. The method of claim **8** wherein the lines are parallel and are spaced apart at a distance less than 1 inch.

10. The method of claim **9** wherein the lines are positioned to form a grid of intersecting parallel lines.

11. The method of claim **10** wherein the parallel lines are spaced apart at a distance less than about 1 inch.

12. The method of claim **3** wherein the dots are arranged in a random matrix pattern.

13. The method of claim **3** wherein the dots are deposited by an inkjet printer having a cross-track to in-track resolution from about 50×300 to about 300×300 dpi.

14. The method of claim **3** wherein at least a majority of the dots each contain from about 20 to about 80 nanograms of phase change composition.

15. The method of claim **3** wherein the dots are from about 10 to about 16 microns in height above the substrate surface.

16. The method of claim **3** wherein the dots contain from about 40 to about 160 nanograms of phase change composition and wherein the dots are from about 10 to about 16 microns in height above the substrate surface.

17. The method of claim **3** wherein the dots contain from about 80 to about 320 nanograms of phase change composition and are from about 20 to about 30 microns in height above the substrate surface.

18. The method of claim **1** wherein the phase change composition is selected from the group consisting of polymeric materials and waxes having a melting point from about 80 to about 130° C., a melting range of less than about 15° C., a crystalline form as a solid, a static coefficient of friction less than about 0.62 and being substantially odorless.

19. The method of claim **18** wherein the melting range is less than about 10° C.

20. The method of claim **18** wherein the phase change composition comprises at least one component selected from the group consisting of waxes, polyethylene, polyalphaolefins, and polyolefins.

21. The method of claim **1** wherein the substrate bearing a toner image is produced by an electrophotographic process.

22. The method of claim **1** wherein the substrate bears a toner image on both the front side and the back side and wherein the phase change composition is deposited on both sides of the substrate.

23. The method of claim **1** wherein the substrate is paper.

24. A method of reducing rub-off from a substrate having a front side and a back side and bearing a plurality of printer or digital copier produced toner images on side, the method comprising depositing a substantially clear phase change composition on at least a portion of the toner images as a plurality of the dots cumulatively covering an area of the toner images sufficient to reduce rub-off from the front side.

25. The method of claim **24** wherein the dots cumulatively cover from about 0.25 to about 8.00 percent of the images.

26. The method of claim **24** wherein the dots are deposited by an ink jet printer.

27. The method of claim **26** wherein the dots are arranged in a matrix pattern.

28. The method of claim **27** wherein the dots are deposited by an ink jet printer having a cross-track to in-track resolution from about 50×300 to about 300×300 dpi.

29. The method of claim **28** wherein the resolution is at least about 100×300 dpi.

30. The method of claim **27** wherein the dots are arranged in a random matrix pattern.

31. The method of claim **26** wherein at least a majority of the dots contain from about 20 to about 80 nanograms of phase change composition.

32. The method of claim **1** wherein the dots are from about 10 to about 16 microns in height above the substrate surface.

33. The method of claim 24 wherein the phase change composition is selected from the group consisting of polymeric materials and waxes having a melting point from about 80 to about 130° C., a melting range of less than about 15° C., a crystalline form as a solid, static coefficient of friction less than about 0.62 and being substantially odorless.

34. The method of claim 33 wherein the range is less than about 10° C.

35. The method of claim 33 wherein the phase change composition comprises at least one component selected from the group consisting of waxes, polyethylene, polyalphaolefins, and polyolefins.

36. The method of claim 24 wherein the substrate has a toner image on both the front side and on the backside and wherein the phase change composition is deposited on the toner images on both sides of the substrate.

37. The method of claim 24 wherein the substrate is paper.

38. The method of claim 24 wherein the dots are deposited in rim areas of the toner images.

39. The method of claim 24 wherein the dots are deposited on the toner images and on the adjacent areas of the substrate.

40. A method of reducing rub-off from a substrate having a front side and a back side and a plurality of printer or digital copier produced printed images on its front side, the method comprising depositing a substantially clear phase change composition on at least a portion of the printed images as a plurality of dots, the dots cumulatively covering an area of the printed images sufficient to reduce rub-off from the front side.

41. The method of claim 40 wherein the dots cumulatively cover from about 0.25 to about 8.00 percent of the printed images.

42. The method of claim 40 wherein the dots are deposited by an ink jet printer.

43. The method of claim 40 wherein the dots are arranged in a matrix pattern.

44. The method of claim 43 wherein the dots are deposited by an ink jet printer having a cross-track to in-track resolution from about 50×300 to about 300×300 dpi.

45. The method of claim 44 wherein the resolution is at least about 100×300 dpi.

46. The method of claim 42 wherein the dots are arranged in a random matrix pattern.

47. The method of claim 42 wherein at least a majority of the dots contain from about 20 to about 80 nanograms of phase change composition.

48. The method of claim 47 wherein the dots are from about 10 to about 16 microns in height above the substrate surface.

49. The method of claim 40 wherein the phase change composition is selected from the group consisting of polymeric materials and waxes having a melting point from about 80 to about 130° C., a melting range of less than about 15° C., a crystalline form as a solid, static coefficient of friction less than about 0.62 and being substantially odorless.

50. The method of claim 49 wherein the phase change composition comprises at least one component selected from the group consisting of waxes, polyethylene, polyalphaolefins, and polyolefins.

51. The method of claim 40 wherein the substrate has a toner image on both the front side and on the backside and wherein the phase change composition is deposited on the toner images on both sides of the substrate.

52. The method of claim 40 wherein the substrate is paper.

53. The method of claim 40 wherein the dots are deposited in rim areas of the printed images.

54. The method of claim 40 wherein the dots are deposited on the printed images and on the adjacent areas of the substrate.

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